Household risk factors associated with dengue-like illness, Republic of Palau, 2000-2001

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SUMMARY **The authors investigated the association between household hygiene status and the occurrence of dengue-like illness (DLI) during the 2000-2001 outbreak in the Republic of Palau. Hygiene status was compared between 55 households with DLI patients and 55 households without DLI patients during the period of the outbreak. Shower facilities with hygienic problems and potential breeding sites of mosquitoes were more frequently found in the lots of households with DLI patients than in those without (OR = 3.1, 95%CI = 1.3-7.2; OR = 3.2, 95%CI = 1.02-9.4, respectively). The total number of hygienic problems was higher for households with DLI patients than for those without (*t*-test, $p = 0.016$). Results indicated that the overall household hygiene status, and particularly the existence of inappropriate shower facilities and mosquito breeding sites, was the predictor of the prevalence of DLI during the outbreak; this status will be considered in the prevention of future outbreaks of DLI in Palau and in other tropical island nations as well.**

Key Words: Dengue-like illness, republic of Palau, hygiene status

Introduction

During the period between September 2000 and December 2001, 887 patients were diagnosed as having "dengue-like illness (DLI)" in the Republic of Palau. This was the third outbreak after the re-emergence of DLI in Palau in 1988 and 1995. DLI re-emerged after a long period that started in 1944; during this period there were no reported incidences of the disease (*1*).

DLI patients, who were diagnosed by medical doctors in a national hospital in Palau on the basis of diagnostic criteria (for details, see Methods), were presumably treated as dengue fever patients. The antibody testing of 338 DLI patients by IgM capture ELISA in the 1995 outbreak revealed that 75% of patients were positive for dengue viruses (*1*). In Palau or other Pacific nations where dengue fever is a major health concern but serological test kits were not always available for diagnosis of dengue fever, a reasonable approach is to study risk factors for DLI by assuming that most DLI cases were caused by dengue viruses.

Dengue fever is primarily a disease of the tropics, and responsible viruses are maintained in a cycle that involves humans and some species of *Aedes* mosquito. The distribution of dengue has expanded and an estimated 2.5 billion people live in areas at risk of epidemic transmission (*2*). According to a survey in Palau during the DLI outbreak in 1995 (*1*), the prevalent mosquitoes were *Ae. aegypti*, *Ae. albopictus*, *Ae. hensilli*, *Ae. palauensis*, and *Ae. scuttelaris*; the first two species were not reported in the survey by Bogart in the 1950s (*3*) and thus were probably introduced between the 1950s and 1995. These species of mosquitoes are sedentary and prefer to feed on humans.

In the present study, the authors hypothesized that household hygienic problems related to the breeding of mosquitoes were associated with the occurrence of DLI in the household. The authors compared the hygiene status of households that had at least one DLI patient

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during the outbreak period to that of households that did not have any DLI patients. The objectives were to investigate the association between overall household hygienic status and DLI occurrence and to identify specific household environmental factors that influence the risk of DLI occurrence.

Methods

The Republic of Palau comprises the western-most group of the Caroline Islands in Micronesia (Figure 1). Of the 340 islands in the Republic, Babeldaob, which occupies 70% of the total land area of the country (488 km^2), is the largest. The capital city is in Koror State located southwest of Babeldaob. More than 70% of the total national population inhabited the capital with an area of 12 km (*i.e.*, the total area of populated islands in Koror State) in 2000 (national population, 19,129; population in Koror, 13,303) (*4*). The country is administratively divided into 16 states, each of which is further divided into hamlets. Most administrative functions and economic sectors are concentrated in Koror. The national hospital and two private clinics are also located in Koror.

According to the database of DLI surveillance of the Division of Environmental Health (DEH), 887 people were diagnosed as having DLI by medical doctors in a national hospital between September 2000 and December 2001. The incidence of DLI during the above period exceeded the estimated number of patients diagnosed as having the viral syndrome during the non-outbreak period in 1993 and 1994 (*i.e.*, 4.5 per week throughout Palau) (*1*). The incidence of DLI peaked in January 2001 (*i.e.*, 212 DLI patients diagnosed in Palau) and gradually decreased to the level of the non-outbreak period in January 2002.

Patients showing febrile illness in Koror and Airai States visited a national hospital or two private clinics

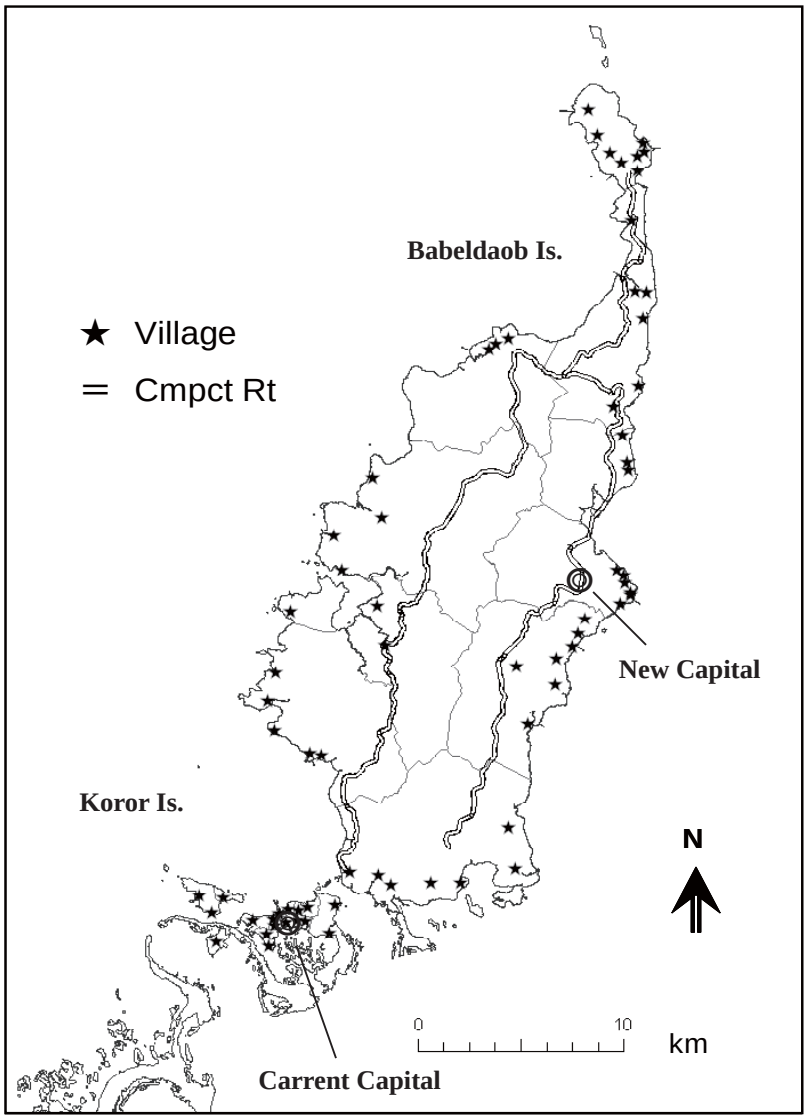

Figure 1. Koror and Babeldaob Islands in Republic of Palau. The locations of the new capital and new highways are indicated. The administrative boundaries shown on the map correspond to those of states.

Table 1. Comparison of 55 households with at least one dengue-like illness (DLI) patient and 55 households without (control) in terms of household hygiene problems between September 2000 and December 2001, Republic of Palau.

Category	Problems	Number of households with problems (% total) DLI *n* = 55	Control *n* = 55	OR	95%CI
Existence of breeding sites					
Mosquitoes	Actual	9 (16.4)	6 (10.9)	1.6	0.5 - 4.8
	Potential	13 (23.6)	5 (9.1)	3.1	1.02 - 9.4
Rats	Actual	8 (14.5)	4 (7.3)	2.2	0.6 - 7.7
	Potential	9 (16.4)	13 (23.6)	0.6	0.2 - 1.6
Flies	Actual	12 (21.8)	6 (10.9)	2.3	0.8 - 6.6
	Potential	6 (10.9)	5 (9.1)	1.2	0.4 - 4.3
Problems with facilities					
Shower	Poor drainage	23 (41.8)	11 (20.0)	2.9	1.2 - 6.7
	No proper building	7 (12.7)	1 (1.8)	7.9	0.9 - 66.0
Kitchen	Poor drainage	18 (32.7)	11 (20.0)	1.9	0.8 - 4.6
	Attracts flies and rats	5 (9.1)	2 (3.6)	2.7	0.5 - 14.3
Toilet	Lacking	2 (3.6)	0	NA	
	Full pit	1 (1.8)	0	NA	
	Screen on holes /no screen	14 (25.5)	11 (20.0)	1.4	0.6 - 3.3
	Door not self-closing	7 (12.7)	8 (14.5)	0.9	0.3 - 2.6
Trash site	Trash container without lid	0	1 (1.8)		
	Improper trash dump	8 (14.5)	6 (10.9)	1.4	0.4 - 4.3
Water tank	Without lid or stand	0	1 (1.8)	NA	
Conditions of plot					
Pigsty	No cesspool or septic tank	4 (7.3)	1 (1.8)	4.2	0.5 - 39.2
Yard	Overgrowth of grass	9 (16.4)	7 (12.7)	1.3	0.5 - 3.9
	Trash/litters found	21 (38.2)	17 (30.9)	1.4	0.6 - 3.0
Total number of problems					
	Mean (SD)	3.2 (2.6)	2.1 (2.0)	$p = 0.017$ (*t*-test)	

Table 2. Comparison of 55 households with at least one dengue-like illness (DLI) patient and 55 households without (control) in terms of household hygiene status by category between September 2000 and December 2001, Republic of Palau.

Category	Number of households with problems (% total) DLI *n* = 55	Control *n* = 55	OR	95%CI
Mosquito	18 (32.7)	10 (18.2)	2.2	0.9 - 5.3
Rat	17 (30.9)	17 (30.9)	1	0.4 - 2.2
Flies	18 (32.7)	10 (18.2)	2.2	0.9 - 5.3
Shower	24 (43.6)	11 (20.0)	3.1	1.3 - 7.2
Kitchen	20 (36.4)	11 (20.0)	2.3	0.97 - 5.4
Toilet	19 (34.5)	14 (25.5)	1.5	0.7 - 3.5
Trash	8 (14.5)	7 (12.7)	1.2	0.4 - 3.5
Water	0	1 (1.8)	NA	
Pig	4 (7.3)	1 (1.8)	4.2	0.5 - 39.2
Yard	25 (45.5)	20 (36.4)	1.5	0.7 - 3.1
Total number of categories in which problems were found;				
Mean (SD)	2.8 (2.2)	1.9 (1.7)	$p = 0.016$ (*t*-test)	
Total number of categories (except for shower) in which problems were found;				
Mean (SD)	2.3 (2.0)	1.7 (1.6)	$p = 0.046$ (*t*-test)	

for diagnosis, whereas those living outside Koror and Airai visited local health clinics. Each health clinic is obligated to transfer suspected DLI patients to a national hospital for diagnosis and treatment by medical doctors. The diagnostic criteria in the hospital included fever (38.5°C) with body or joint aches, headache, myalgia, asthenia and rashes. Since September 2000, the staff of DEH have checked the national hospital and

private clinics daily and recorded the name, sex, age, and place of residence of DLI patients.

In 2001-2002, the DEH staff inspected the hygiene status of all households in 13 states (those located outside Koror and Airai). The status, as indicated by 10 categories (mosquito breeding sites, rat breeding sites, fly breeding sites, shower facilities, kitchen, toilet, trash site, water tank, pig sty, and yard), was investigated by a pair of trained inspectors (one inspector evaluated the state of the problem and the other inspector recorded findings after confirming the state) on the basis of a structured checklist (20 hygiene problems in total) (see Table 1 for the hygiene problems evaluated). Abandoned tires, cans, shells of giant clams, cooler boxes, coconut shells, flower pots, boats, and puddles on the ground were regarded as the breeding sites of mosquitoes, whereas holes on the ground and the leavings of a meal or dung were those of rats and flies, respectively. Those breeding sites were examined for evidence of breeding ("actual" breeding sites) or not ("potential" breeding sites). Evidence of breeding was the existence of larvae or eggs for mosquitoes, excrement for rats, and maggots for flies.

Of the 887 DLI patients, 71 resided in 13 states where household hygiene data were available. The DLI patients were members of 55 households (one household had four patients, three households had three and seven households had two). For each household with a DLI patient (a case, hereafter referred to as a DLI household), a control household was randomly selected from households (**1**) in the same neighborhood (**2**) that had no DLI patients during the 2000-2001 outbreak period and (**3**) that had a member whose age matched (within 5 years) that of the DLI patient in the case household. Household hygiene data for the 55 DLI households and the control households were compared.

Results

In Table 1, household hygiene status of the 55 DLI households and the 55 control households was compared for each of the 20 hygiene problems. For most household hygiene problems, the odds of having problems were higher in the DLI households than in the control households. The lower limit of the 95% confidential interval (CI) of the odds ratio for having problems (reference = control households) exceeded 1 for poor drainage of shower facilities (OR = 2.9, CI: 1.2-6.7) and existence of potential breeding sites for mosquitoes (OR = 3.1, CI: 1.02-9.4). The total number of hygiene problems was statistically significantly higher in the DLI households than in the control households (*t*-test, $p = 0.017$).

Table 2 shows the number of households that have one or more hygienic problem in each category. The odds of having problems were higher in the DLI households than in the control households for most categories. The lower limit of the 95%CI of the odds ratio (reference = control households) exceeded 1 for having problems with shower facilities (OR = 3.1, CI: 1.3-7.2). The total number of categories in which problems were found was statistically significantly higher in the DLI households than in the control households (*t*-test, $p = 0.016$). This tendency did not change even when the problems with shower facilities were not included (*t*-test, $p = 0.046$), which indicated that overall household hygienic status predicted the risk of DLI occurrence.

Discussion

The present analysis of the association of household risk factors with DLI revealed that poor drainage and shower facilities and the presence of potential mosquito breeding sites were significant risk factors for DLI occurrence. In the analysis of the 1995 DLI outbreak in Palau, Ashford *et al*. found that DLI was associated with the existence of food and water pans for animals on the property and taro farming but not with the existence of potential breeding sites for mosquitoes (tires, cans or buckets) (*1*) The lack of the expected association was explained by the high prevalence of mosquito breeding sites in both affected and non-affected households. In the present study, potential mosquito breeding sites were found in only 24% of the DLI households and 9% of the control households. This may reflect the effect of measures to control DLI infection (such as a public education campaign to reduce vector breeding sites and improved solid waste disposal) implemented after the 1995 outbreak. The association between dengue infection and potential mosquito breeding sites became apparent during the period from 1995 to 2001.

Poor drainage of shower facilities was also a significant risk factor for dengue infection. According to the 2000 Census of Population and Housing (*4*), 48% of households outside Koror did not have appropriate waste disposal facilities, whereas 49% connected their sewage to a septic tank or cesspool. Water from the former households usually flows into open drains, which often form puddles suitable for breeding of mosquitoes. Larvae and pupae were usually observed in such places.

Previous studies in other countries commonly indicate that the environmental conditions of residential areas are frequently associated with the risk of dengue infection (*5-7*); individual risk factors varied among the populations because of differences in vector species and breeding site. In a case-control study in Brazil, Heukelbach *et al*. showed that receptacles in the garden or courtyard, plants with temporary water pools on the property, gutters in which rainwater collected, and uncovered water storage areas are significant risk factors for dengue infection (*5*). Koopman *et al*.

emphasized that the characteristics of a community (*i.e.*, the proportion of households with larvae on the premises and the proportion of households with uncovered water containers) are associated with the proportion of the individuals infected (*7*). The present study showed that, in Palau, the risk factors for DLI (presumably dengue fever) during the outbreak period were the overall household hygiene status, existence of mosquito breeding sites, and poor drainage of shower facilities.

The WHO's Healthy Islands initiatives introduced by the Palau government in 1999 were directed toward improving household hygiene by educational campaigns in the communities and practical demonstration of clean drainage and septic tanks using a participatory approach. These initiatives may have improved the people's knowledge, attitude and practice, which are essential for the achievement of improved hygiene. Further implementation will reduce the risk of DLI infection among the populace. Environmental risk factors have effects beyond individual household and individuals infected with DLI create risks for others. The organisation of control measures must be at the community level (*7*).

The Republic of Palau is now in the process of relocating its capital from Koror to the centre of Babeldaob. Road networks linking Koror, the new capital, and other states in Babeldaob are currently under construction. This change in social infrastructure may induce either the migration of Koror residents to their home villages in Babeldaob (*i.e.*, they will commute from their home villages to Koror) or frequent visits of Koror residents to their home villages (every weekend or so), both of which may change the risk of dengue infection for Palauans (*8,9*). Frequent monitoring of both dengue cases as well as household hygiene status are fundamental strategies for the prevention of future outbreaks of dengue fever in the Republic of Palau. This is also the case for other Pacific nations that have recently experienced dengue outbreaks (*e.g.*, Fiji in 1998, Cook Island in 1997, French Polynesia in 2001 and Samoa in 1996) (*10*) or that have yet to experience such outbreaks but share similar physical and social environments and lifestyles.

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References

1. Ashford DA, Savage HM, Hajjeh RA, McReady J, Bartholomew DM, Spiegel RA, Vorndam V, Clark GG, Gubler DG. Outbreak of dengue fever in Palau, Western Pacific: risk factors for infection. Am J Trop Med Hyg 2003;69:135-140.
2. Guzman MG, Kouri G. Dengue: an update. Lancet Infect Dis 2002;2:33-42.
3. Bogart RM. Insects of Micronesia, Diptera: Culicidae. Bernice P. Honolulu: Bishop Museum, Insects of Micronesia 1956;12.
4. Office of Planning and Statistics. Census of Population and Housing of the Republic of Palau. Koror: Office of Planning and Statistics, 2000.
5. Heukelbach J, De Oliveira FA, Kerr-Pontes LR, Feldmeier H.. Risk factors associated with an outbreak of dengue fever in a favela in Fortaleza, north-east Brazil. Trop Med Int Health 2001;6:635-642.
6. Hayes JM, Garcia-Rivera E, Flores-Reyna R, Suarez-Rangel G, Rodriguez-Mata T, Coto-Portillo R, Baltrons-Orellana R, Mendoza-Rodriguez E, De Garay BF, Jubis-Estrada J, Hernandez-Argueta R, Biggerstaff BJ, Rigau-Perez JG. Risk factors for infection during a severe dengue outbreak in El Salvador in 2000. Am J Trop Med Hyg 2003;69:629-633.
7. Koopman JS, Prevots DR, Vaca Marin MA, Gomez Dantes H, Zarate Aquino ML, Longini IM, Sepulveda Amor J. Determinants and predictors of dengue infection in Mexico. Am J Epidemiol 1991;133:1168-1178.
8. Nagao Y, Thavara U, Chitnumsup P, Tawatsin A, Chansang C, Campbell-Lendrum D. Climatic and social risk factors for Aedes infestation in rural Thailand. Trop Med Int Healh 2003;8:650-659.
9. Reiskind MH, Baisley KJ, Calampa C, Sharp TW, Watts DM, Wilson ML Epidemiological and ecological characteristics of past dengue virus infection in Santa Clara, Peru. Trop Med Int Health 2001;6:212-218.
10. WHO Western Pacific Regional Office. Dengue fever/ dengue haemorrhgic fever and its control: status in WHO's Western Pacific region by 1999. Manila: WHO Western Pacific Regional Office, 2001.